R E S T R I C T E D C I R C U L A T I O N

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Agricultural Memorandum No 679.

CALCULATION OF AN INDEX FOR SPORULATION OF THE EYESPOT FUNGUS

BY J B TYLDESLEY

1. Background. Eyespot, sometimes known as footrot, is a disease of cereals caused by the fungus Cercosporella herpotrichiodes. The lesions at the base of the stem make the crop prone to lodging. They also reduce yield by cutting off nutrients from the upper part of the plant. Infection is carried over on stubble trash, and spread by rainsplash. The fungus sporulates freely in mild damp weather, and although most cereals can be infected, damage is most severe in winter wheat. Most varieties of winter wheat grown in Britain have good resistance to the disease, but nevertheless it is on the increase. Continuous cereal growing and reduced cultivations are likely to be involved, and climatic factors such as the recent run of mild winters may also play a part.

2. Index of Sporulation. It has been known for some time that temperatures around 10°C are most favourable for sporulation. In a recent article Rowe and Powelson put this on a quantitative basis (Epidemiology of Cercosporella Footrot of Wheat: Spore Production. Phytopathology 63 981-984, August 1973). They define an Equivalent Unit Value (EUV) which is shown diagramatically in fig 1, from the verbal description in the paper. It represents the short-term response of the fungus to ambient temperatures, as far as sporulation is concerned, and summarises to a reasonable approximation the results of a large number of experiments both in the laboratory and the field. The response to temperature is nil below 0°C. It increases linearly from 0°C to a maximum at 10°C, after which it decreases linearly to zero at 20°C. Temperatures above 20°C are considered to be definitely adverse and this is represented by a continuing decrease of the EUV to negative values at higher temperatures.

Rowe and Powelson then define a Daily Thermal Sporulation Coefficient (DTSC) as the integral over the twenty-four hours of the EUV. The units are deg C x hours, and the maximum value of the DTSC is 240, attained when a temperature of 10°C is sustained for 24 hours. Rowe and Powelson found the DTSC by exposing thermographs in screens on the trial plots. They evaluated the area bounded by the temperature curve and the 0° and 10°C lines by counting squares, similarly the area of the curve above the 10°C line, and subtracted the two to get the DTSC.

3. Evaluating the DTSC by a degree-day method. Fig 2 shows an idealised daily thermograph curve, spanning the two break points in the response curve of fig 1. Below the graph are given the EUVs for the segments of the curves defined by these break points. It is clear that if

area C D E F G = A

and area C D G = B

then the DTSC = A - B (units; °C x hours)

as given by Rowe and Powelson.

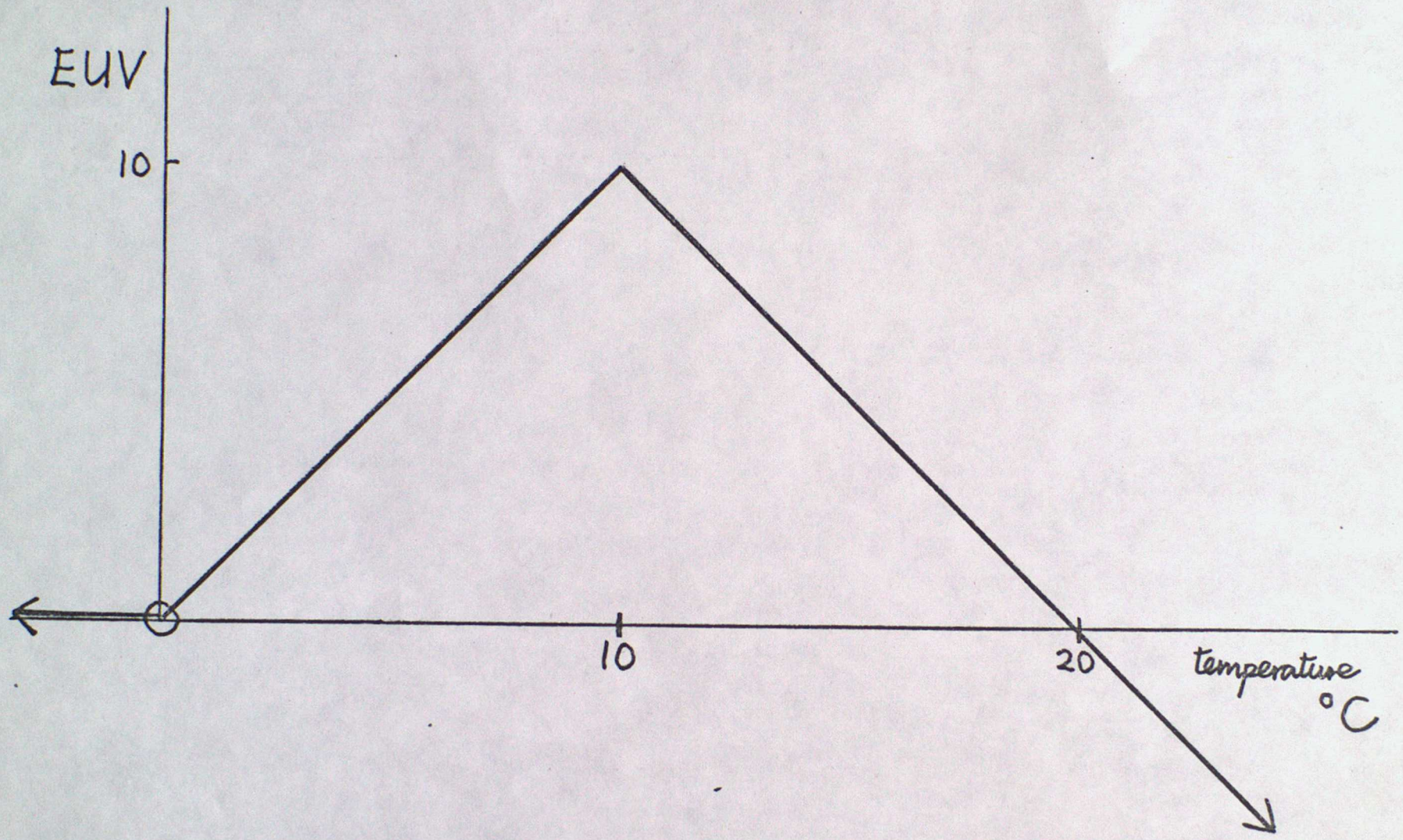

Fig 1 . Equivalent Unit Value (EUV) as a function of temperature

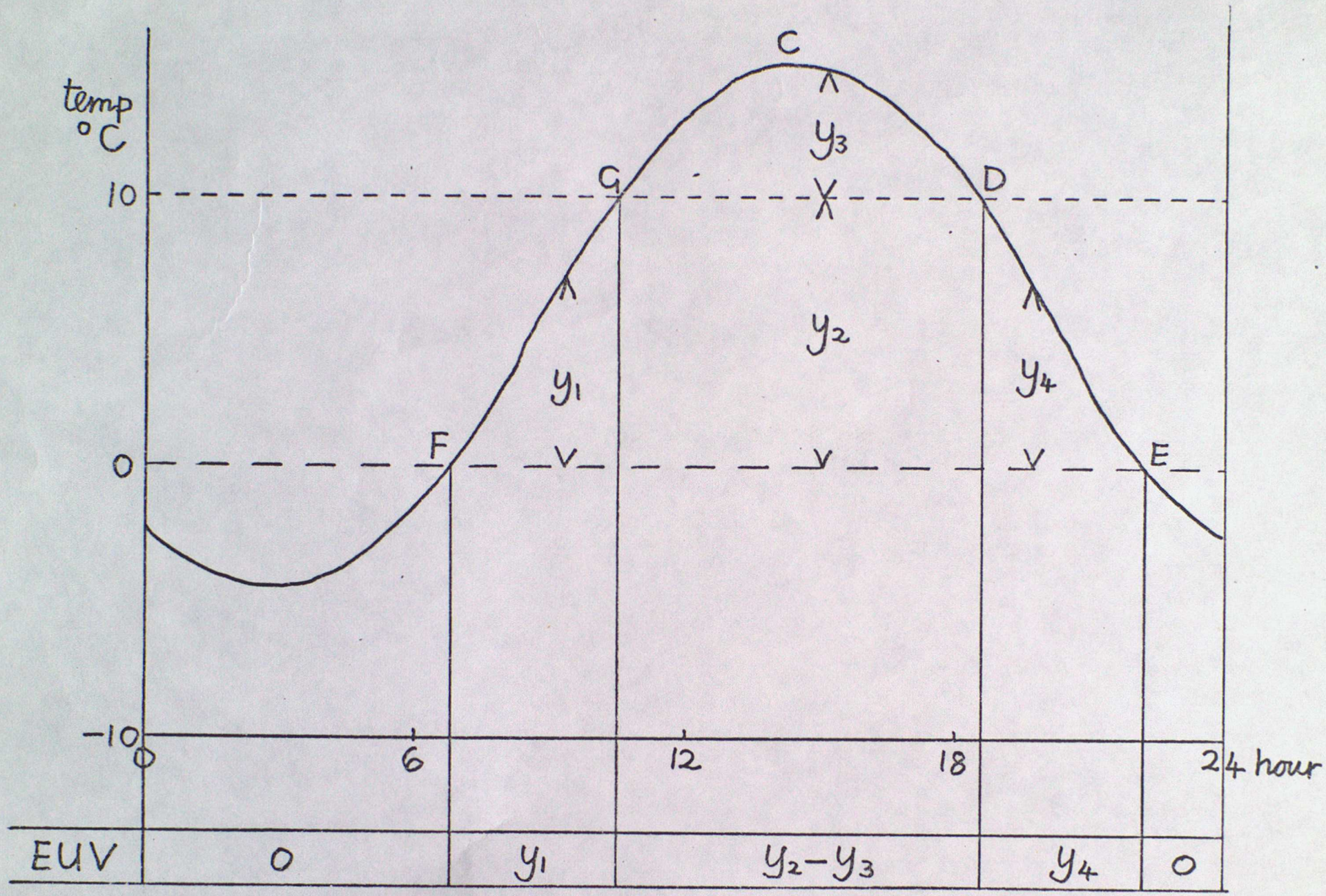

Fig2. Evaluating the Daily Thermal Sporulation Coefficient (DTSC) from the Equivalent Unit Value (EUV) and the daily temperature curve.

However

$$DTSC = A - B = (A + B) - 2B$$

$$= 24 \left[(^{\circ}C \text{ days above } 0^{\circ}C) - 2(^{\circ}C \text{ days above } 10^{\circ}C) \right]$$

This relation makes it possible to eliminate the tedium of counting squares on thermo-grams, and substitute oneor other of the short-cut methods which have been devised for rapid estimation of degree-days. If monthly means of the DTSC are wanted, then Thom's method, in the graphical version given by Harvey in Ag Mem 527 may be used. This requires only monthly mean temperature and standard deviation of monthly mean temperature. The latter may be obtained from the maps in Shellard's Prof Note 125. Fig 3 gives monthly mean values of DTSC at Leeming for two recent years, obtained in this way.

If daily values of the DTSC are required, then the tables or formulae of Met O Leaflet No 10 may be used, entering them with the maximum and minimum temperatures for the day. By this means it was possible to prepare a table giving the DTSC in terms of all maximum and minimum temperatures likely to be encountered in grain-growing areas of Britain. The body of this table can be divided according to the levels of sporulation indicated by Rowe and Powelson and given in table 1.

Table 1.

DTSC	LEVEL OF SPORULATION
less than 50	minimal
50–120	moderate
more than 120	heavy

The result is shown diagramatically in fig 4. Clearly, the details of this picture are somewhat artificial, being artefacts of the break points of the response curve of fig 1 and the coefficients in the formulae used for calculating the degree-days, but the general picture is coherent. Points above and to the left of the broken diagonal line represent days with a diurnal temperature range of more than 25°C and are not likely to occur, indeed most days will be well below and to the right of this line. It is clear that in Britain the DTSC will be in the "moderate" or "heavy" categories on most days in the year, "minimal" only occurring in unusually hot or cold weather. This was confirmed by working out a year's daily values for Leeming, as shown in table 2.

Table 2. Number of days at Leeming in 1974 falling in different ranges of the DTSC.

	Month											
DTSC	J	F	M	A	M	J	J	A	S	O	N	D
less than 50	3	2	1	0	0	0	2	2	0	0	2	0
50–120	9	10	17	6	2	9	15	18	6	2	9	6
more than 120	19	16	13	24	29	21	14	11	24	29	15	25

Though the table confirms the spring and autumn maxima shown in fig 3, it is clear that subject to the availability of sufficient moisture, sporulation may occur freely at any time of year.

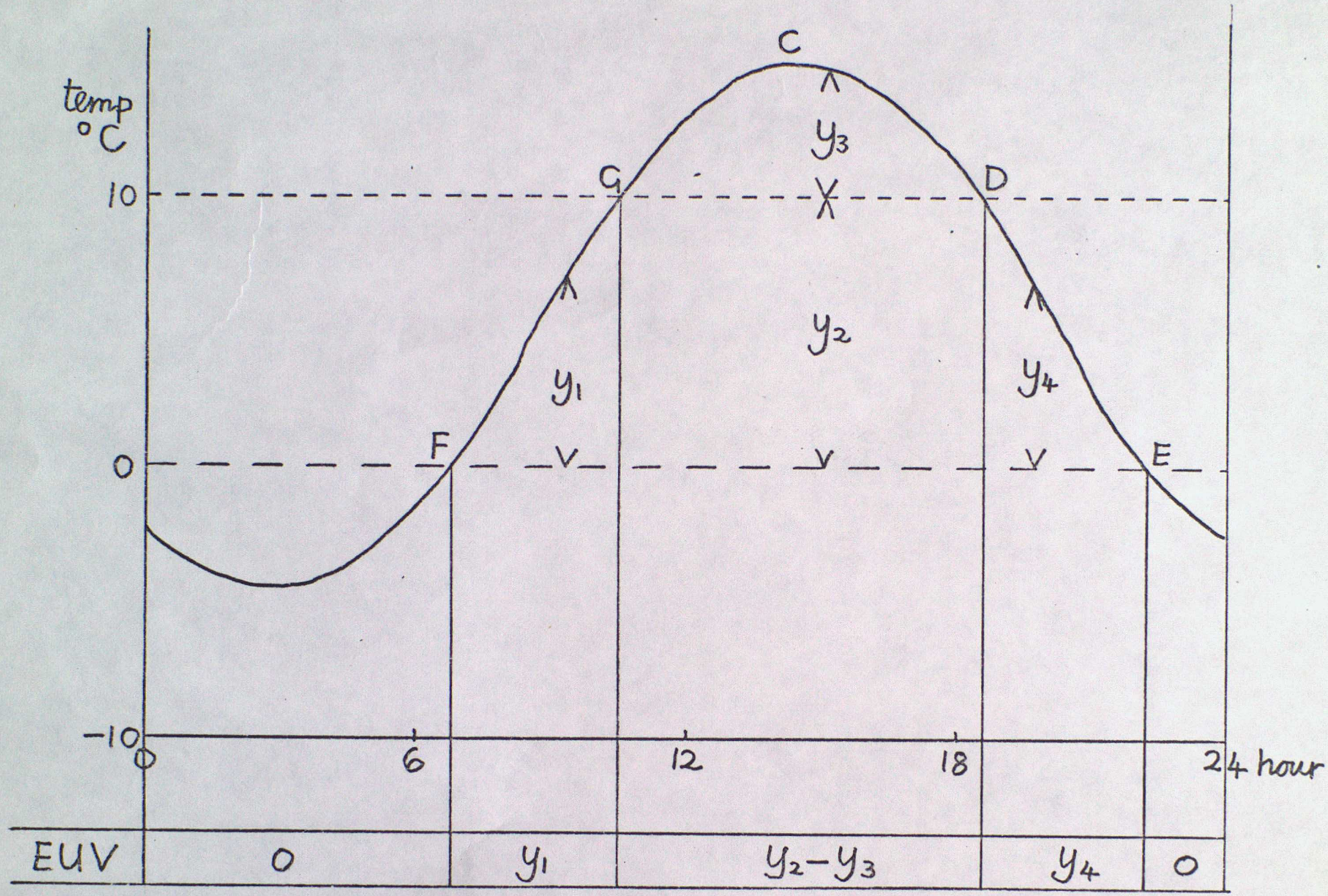

Fig2. Evaluating the Daily Thermal Sporulation Coefficient (DTSC) from the Equivalent Unit Value (EUV) and the daily temperature curve.

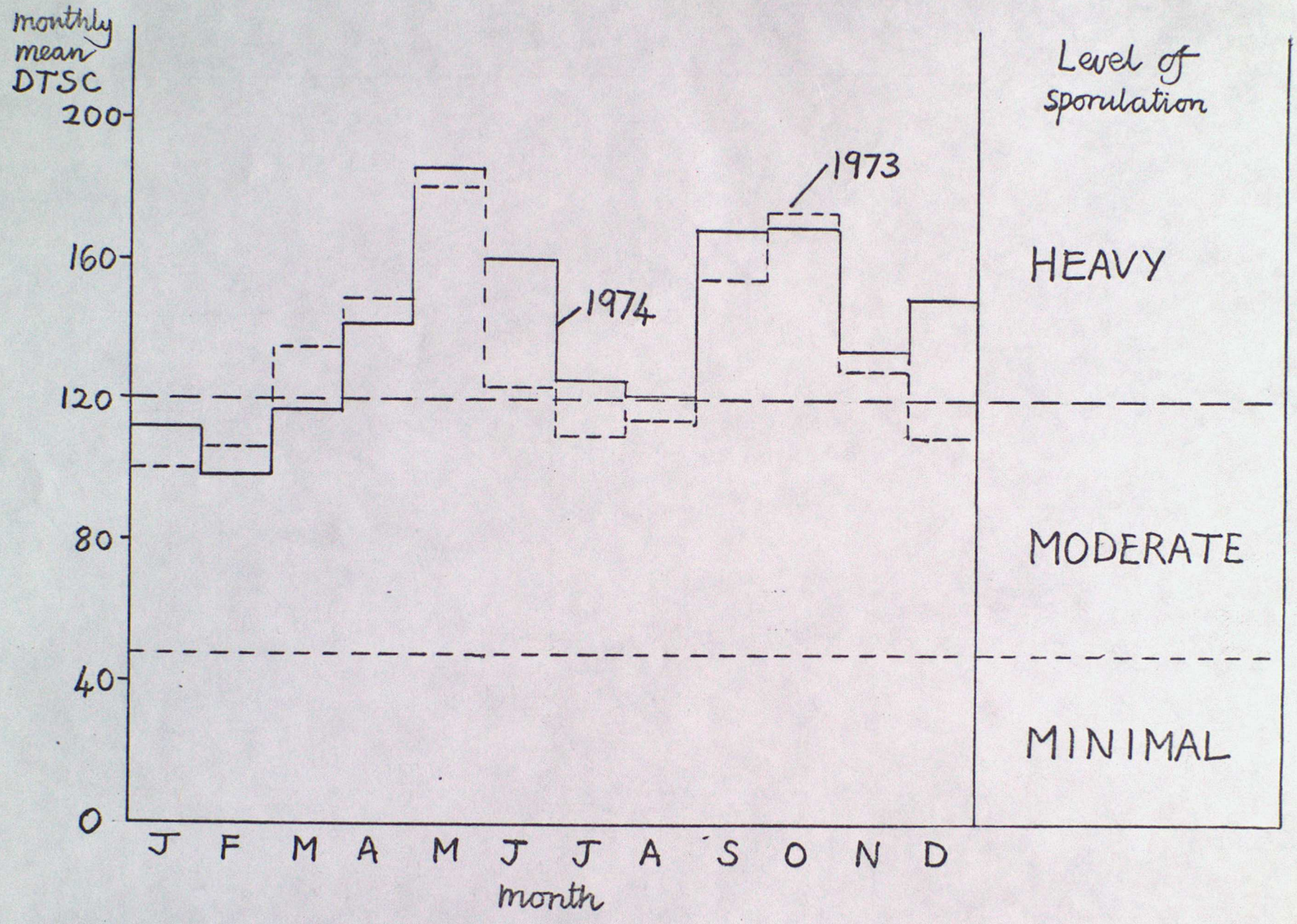

Fig 3. Monthly mean values of DTSC at Leeming for 1973 and 1974.

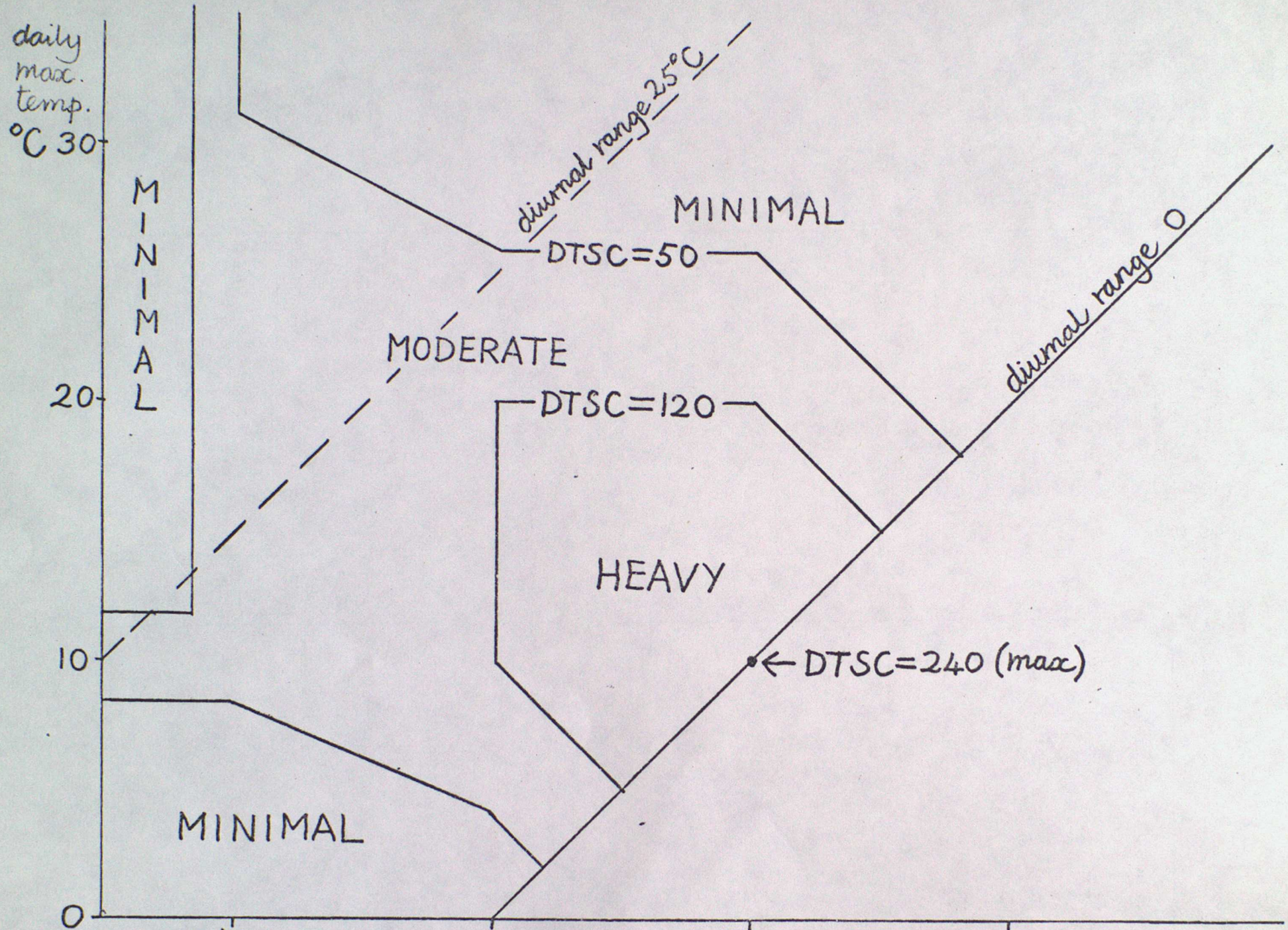

Fig 4. Different levels of DTSC in terms of daily maximum and minimum temperatures. For definitions see Table 1.

4. Discussion. It has been shown that the Daily Thermal Sporulation Coefficient may readily be calculated on a daily and monthly basis, though to define the active sporulation periods there is a need to incorporate the requirement for adequate soil moisture. It appears that conditions favourable for sporulation are frequent at all times of year in Britain. Free sporulation is only one of the requirements for Cercosporella to produce damaging levels of eyespot disease, and it is not yet clear if it is a critical one. Finally, the following quotation from Rowe and Powelson's paper may be relevent.

> "In the wheat-growing areas of eastern Oregon where foot rot is a problem, conditions favoring active sporulation occur only sporadically from November to May, the total rarely exceeding 100 days. At any one location, sporulation is only limited by weather patterns and can be expected wherever conditions are favorable. In western Oregon where ideal conditions of temperature and moisture prevail almost continuously, starting in October, the inoculum would soon be exhausted. This may partially explain the almost total absence of foot rot west of the Cascade Mountains, in spite of the very favorable climate for this disease".

Any comments or suggestions on this paper should be referred to the author.

Meteorological Office
Ministry of Agriculture, Fisheries and Food
Windsor House
Cornwall Road
Harrogate
North Yorkshire

January 1975.